WBS 6.1: Pixels Phase-II Upgrade

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Outline

- Introduction.
- ITk Options and Cost.
- Pixel Volume.
- ITk Common Items.
- US Deliverables.
- Module Assembly.
- WBS Structure.

Introduction

- Layout and High eta TFs still at work to answer fundamental questions: Strips/Pixels volumes, # Pixels layers, Pixels disks/rings, eta coverage, etc…

  Conclusions by end of 2015.

- Pixels layouts: I-Beams (LBNL), Alpine (LAPP) and SLIM (Geneva, initially targeting 5th Pixel Layer CMOS), Unity (long inner barrel, LBNL/UK).

  4/5/6 Pixels Layers.

  2 (3) options for TDR (2017).

- Costing exercise also still at work.

  Preliminary report for LHCC June meeting – Final fall 2015.

  Need completion of Costing exercise to make plans (US Contributions/Cost).

ITk Options

(Steve/Claudia at recent ITk Week)

Descope - Option	200MCHF option	235MCHF option	275MCHF option
Barrel 3 + 1 disc set (saves 24 MCHF)	Y		
Stub (saves 2 MCHF)		Y	
2 “outer Layers” (saves 3 + 4 MCHF)	Y		
Eta coverage to =2.7 (saves 12 MCHF)			
Eta coverage to ~3.2 (saves 6 MCHF)	X	X	
Eta coverage to =4.0 (saves 0 MCHF)			X
Saving in MCHF	**37**	**8**	**0**
ITk Cost	**97.8**	**126.8**	**134.8**

Y=removed from a high-eta LoI-like configuration
X=limit of eta coverage
Note here “outer layer” means one side of strip module

ITk Cost

- All descoping/costing costs assume LOI layout.
- We won't build it! LOI gives us a *cost* reference, which is hopefully conservative.

Extension of Pixel Volume?

- Pixel volume being revisited (vs LOI) to allow 5th Pixel Layer.
- Flat ITk cost: Strips cost needs to go down. Remove Strips layer.
- 5th Layer technology *likely* different (cheaper) from other layers.
- Leaves room for a 6th layer, if cheap technology becomes available and/or cheap design matures (that saves surface, eg alpine-like).
- 5th barrel layer also means more rings.

	4-Layer Pixels	5-Layer Pixels*
Si Area (m^2)	9.5	14.4
# of Modules	6436	9630
Cost (MCHF)	28.6	40.6
Module Cost (MCHF)	16.6	23.2

* Lots of assumptions!

ITk Common Items

- No L2 General ITk, so some items have to fall into Pixels or Strips.
- Most of common items lead to deliverables related to Pixels. So decided with Carl to have all Common items in the Pixels WBS structure. Not all items lead to deliverables.

- Common items:
  - High Speed Optical Readout.
  - DAQ and test systems (HSIO-II and FELIX).
  - Testbeams and irradiations.
  - Sensors: 3D, CMOS (Strips and Pixels).
  - Global Mechanics (see next).

US Deliverables - Pixels (Common ITk)

US deliverables are pretty much the same as last year's ITk meeting in UCSC:

- Readout chip.

  Design, production wafer probing.
- Sensors: 3D and CMOS.

  Likely no deliverables, but design/prototyping.
- Module assembly and testing.

  Likely 20% of whole production (see next).
- Local Supports.

  Main actor of design/prototyping of I-Beams. Whole mechanical production in US.
- High Speed electrical readout (stave-PP0).

  Lots of developments in the US (twisted pairs, kapton flex, twinax). Production experience with IBL.
- High Speed optical readout (PP1-USA15).

  Need more bandwidth than present versatile link. R&D in the US.
- Stave assembly?

  Stave assembly in the US? Ideally done close/at CERN, but might be required.

US Deliverables – Global Mechanics

Inputs from Eric Anderssen:

- Integration.

  Layout support, Global Envelope model, Service integration (strips/pixels), thermal management,
- Global Support Structures.

  Structure design and fabrication for Pixel Support Tube, Insertable Pixel Supports, Pixel Barrel Supports, contribute to design of Outer Barrel.
- Surface Assembly.

  Assembly tooling/process definition (mostly pixel), assembly effort/oversight
- Installation (underground).

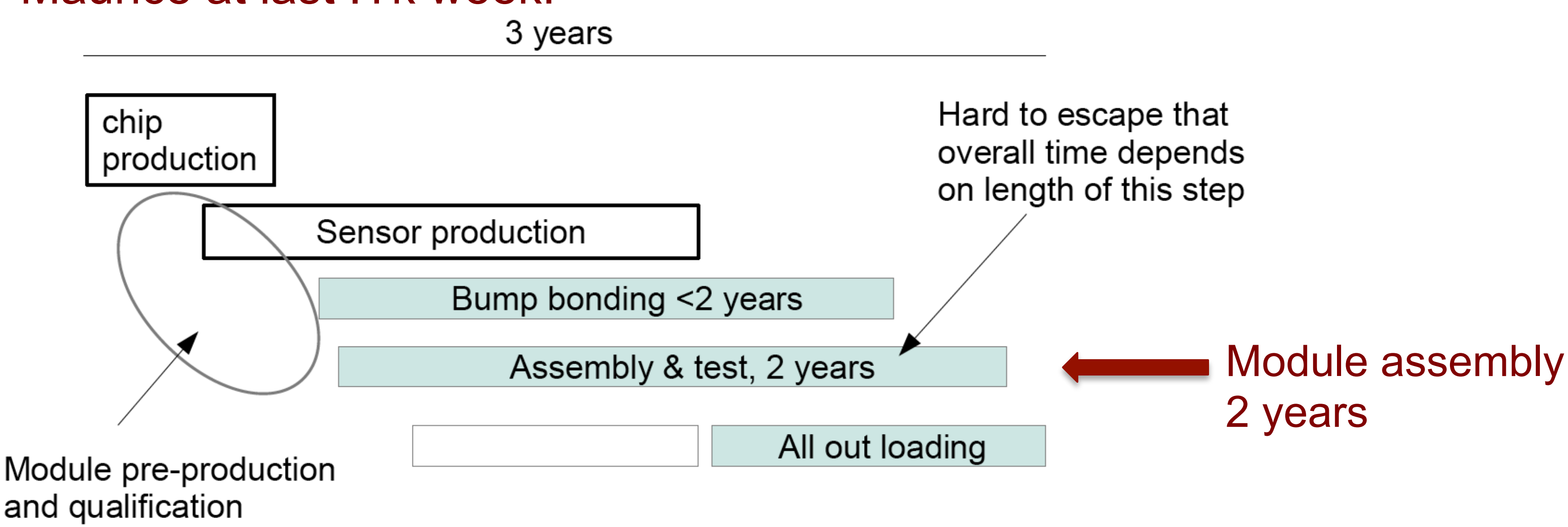
  Process planning, tooling design, service connection, installation effort/oversight.

Installation will have some overlap with current M&O operations, i.e. decommissioning.

Module Assembly

	4-Layer Pixels	5-Layer Pixels
Si Area (m^2)*	9.5	14.4
# of Modules*	6436	9630
Cost* (MCHF)	28.6	40.6
Module Cost* (MCHF)	16.6	23.2

Maurice at last ITk week:



Module Assembly

- Number of Modules to assemble (4-layer Pixels), including spares: 7000 !
- US share (20%): 1400 modules.
- Rate: ~20 modules/week. Might need higher rate (more modules / less time).
- For current Pixels, rate was ~10 modules/week/site.

- Working assumption/proposal (to be discussed):
  - Few assembly sites: UCSC, LBNL and SLAC. May need only two: 10 mod/week/site.
  - Testing: more institutes involved:
    - Ship assembled modules to Institutes?
    - Institutes people come to assembly sites?
- What happens if Stave Assembly required?
- Dummy pre-production in 2015/2016?
  - Currently NOT involved in Modules developments.
  - Launch pre-production of dummy quad modules to learn/practice?

WBS – L3

Updated inputs from all Institutes (13 Institutes)

- 6.1.1 Local Supports I-Beams.

  LBNL, SLAC.

  - 6.1.1.1 Production (mechanics) of I-Beams.
    - 6.1.1.1.1 Design.
    - 6.1.1.1.2 Prototyping.
    - 6.1.1.1.3 Production.
- 6.1.2 Readout FE Chip.

  LBNL, U of Washington.
- 6.1.3 Modules.

  UCSC, LBNL, SLAC, UNM, U of Oklahoma, UT Dallas.
- 6.1.4 Off Detector Electronics (EoS, Type-1, electrical R/O; common items).

  UCSC, SLAC, UNM, Ohio SU, Oklahoma SU, U of Oklahoma.
- 6.1.5 High Speed Optical Readout.

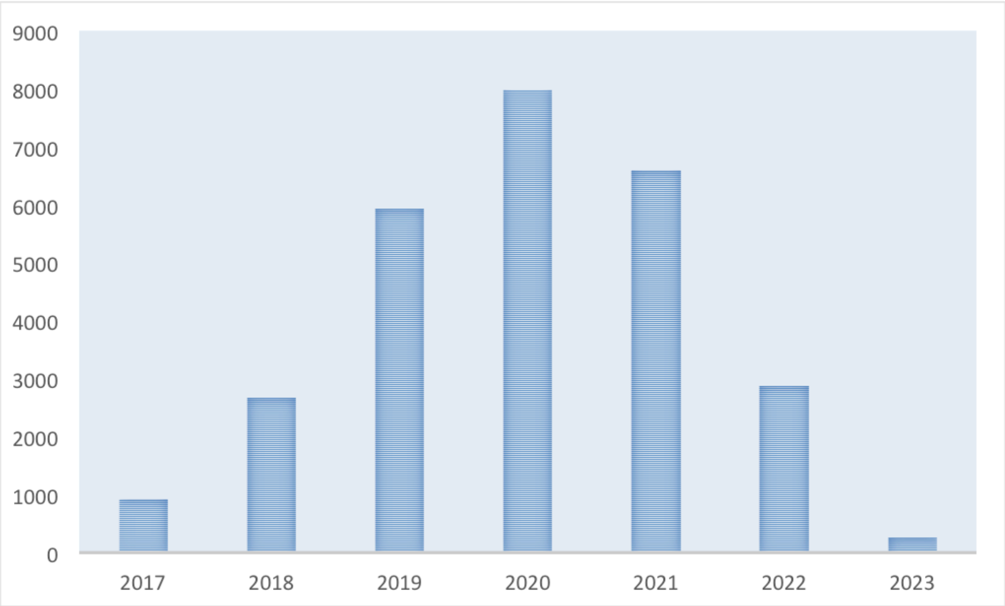
  ANL, LBNL, SMU.

WBS – L3

- 6.1.6 DAQ and Tests Setups.
  SLAC, U of Washington, ANL, Oklahoma SU, Stony Brook.
- 6.1.7 Sensors.
  SLAC, UCSC.
- 6.1.8 Testbeams and Irradiations.
  UNM, SLAC.
- 6.1.9 ITk Mechanics.
  LBNL, SLAC, U of Washington, BNL(?)

Cost – Profile (Pixels PL)

- 2017 (end): TDR.
- 2018 (mid): MoU (before, mainly pre-production 10-15%).
- 2018-2022: Production.
- 2022: Integration.
- 2023: Integration/test/commissioning.



Conclusion

- Still lots of unknowns on major items.
- Layout - Scoping - Pixel Volume.
- Started to work on detailed items (WBS L4). Will update the spreadsheet soon.
- Global Mechanics: Workshop the week after the AUW.

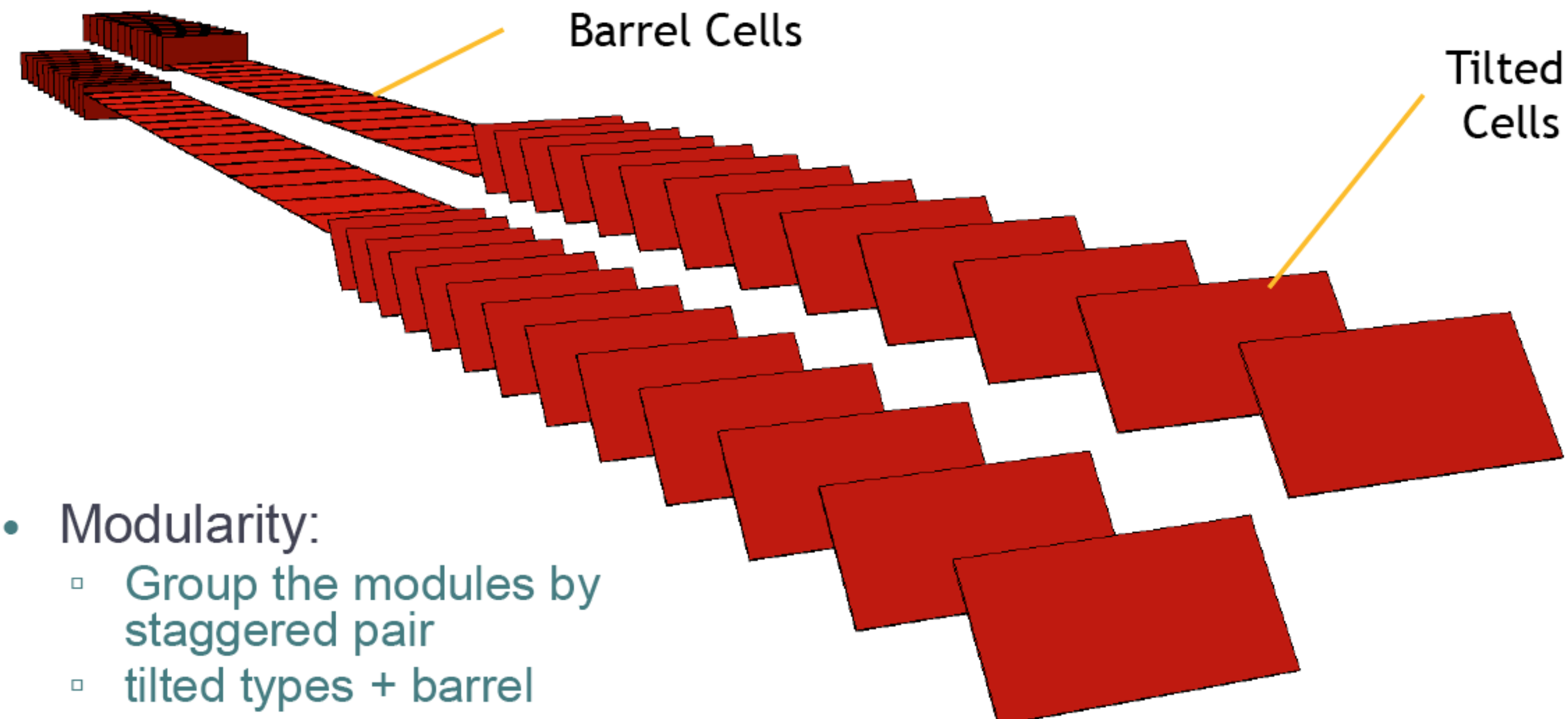
Backup slides

IDR – Barrel Pixels Staves

Detector:	Radial position [mm]	Half Length [mm]	Tilt angle degrees	Staves	Modules/stave
Layer 1	39	456.5	–14	16	22
Layer 2	78	747.0	–14	16	36
Layer 3	155	722.8	–14	32	35
Layer 4	250	722.8	–14	52	35

SLIM

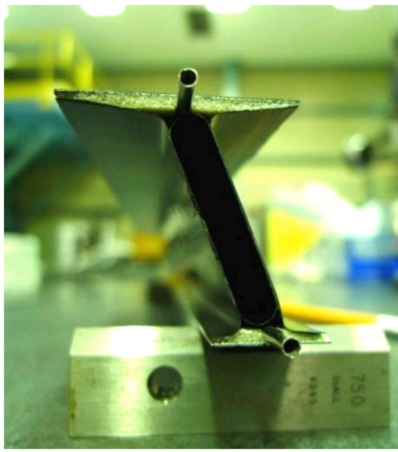
Less surface – lower cost, less heat load, less services

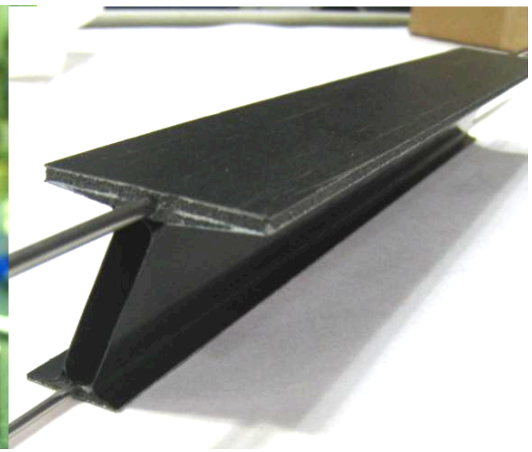


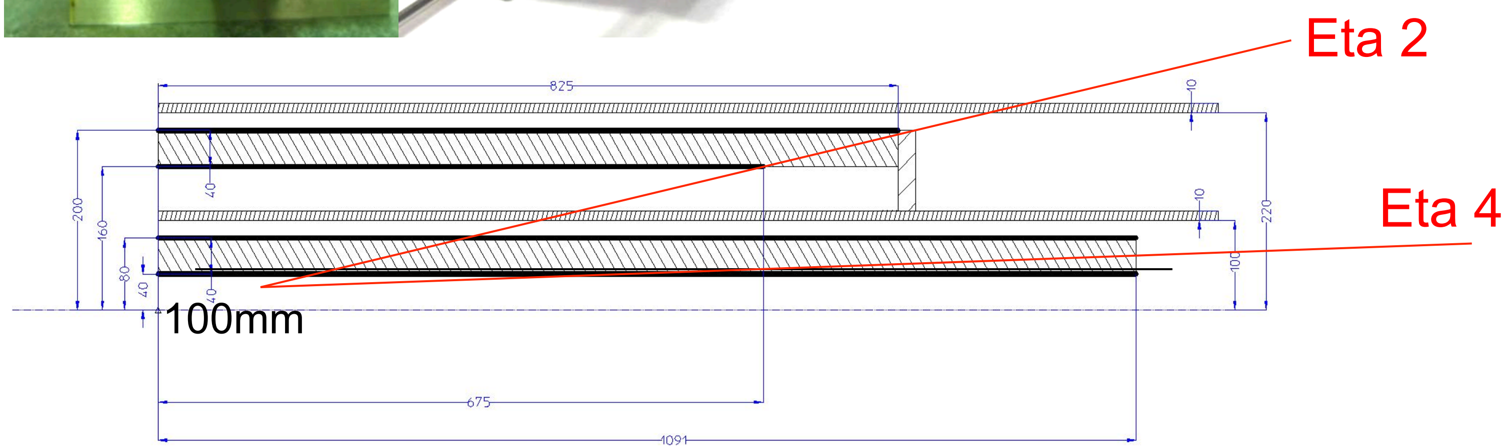
- Modularity:
  - Group the modules by staggered pair
  - tilted types + barrel
  - 1 slim stave is equivalent to two adjacent conventional staves

UNITY

I-Beam barrel, curved staves, high eta with extended inner barrel. Meant to be viewed with optimized end-cap.





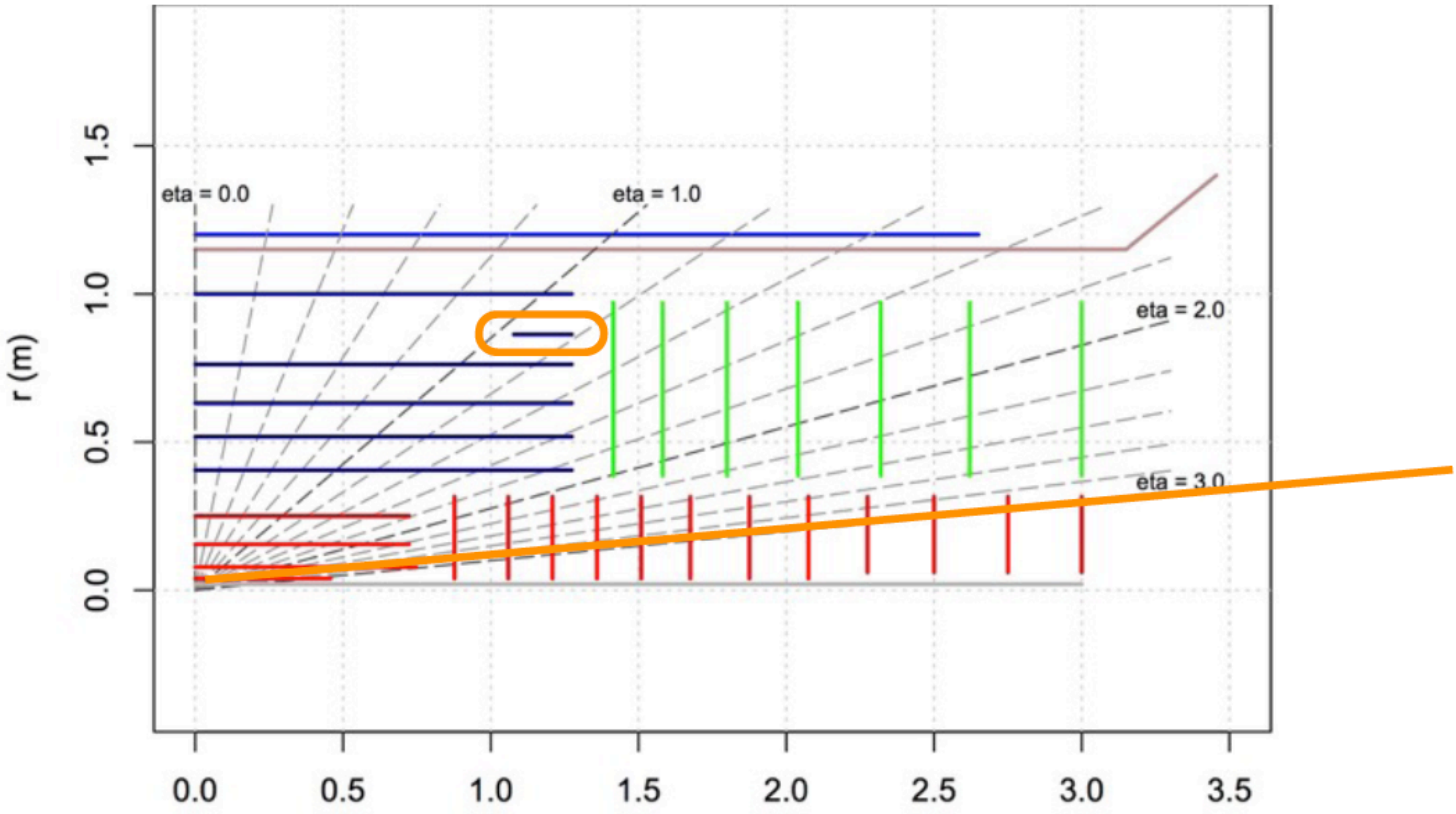


5-6 Layer Pixel Detector

- 5^{th} Layer.
  - Tracking performance (pT, d0, and Z0 resolution) almost identical between 4 and 5 layers. Same for fakes.
  - Improved patter recognition, seeded in the pixel detector.
  - Better two-particle separation in high pT jets.
  - More robust for high pile-up environment.

- $6^{th\ Layer}$: Andy: improved patter recognition.

Descoping – Option B



Descoping – Option C